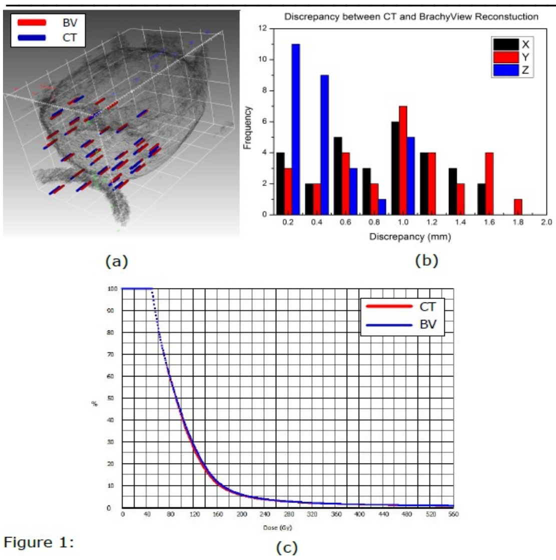

Figure 1:

Conclusion: The reconstructed seed positions measured by the BV probe demonstrate excellent agreement with seed positions calculated using CT data with a maximum discrepancy of 1.78 mm. It was observed that 75% of seed positions were reconstructed within 1 mm of their nominal location. The DVH study was performed to evaluate the effect of reconstructed seed locations on estimated dose delivered. V100 showed a discrepancy of 0.604 cm3 between CT and BV-derived 3D seed distribution. The BV technique has proven to be an effective tool for quality assurance during LDR brachytherapy, providing anatomical and seed positioning information without need for external irradiation for imaging.

OC-0253
A high sensitivity plastic scintillation detector for in vivo dosimetry of LDR brachytherapy

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Purpose or Objective: There are multiple challenges behind developing an *in vivo* dosimeter for LDR brachytherapy. The dose rates are orders of magnitudes lower than in other therapy modalities, the detectors are known to be energy-dependent, and introducing materials that are not tissue-equivalent may perturb the dose deposition. The goal of this work is to develop a high sensitivity dosimeter based on plastic scintillation detectors (PSDs) that overcomes those challenges and to validate its performance for *in vivo* dosimetry.

Material and Methods: The effect of the energy dependence of PSDs on dosimetry accuracy was studied using GEANT4 Monte Carlo (MC) simulations adapted from the ALGEBRA source code developed for brachytherapy. The photon energy distribution at different positions around a modeled I-125 source was obtained and convoluted to a typical PSD response. The effect of the different materials composing the PSD was also investigated.
To measure dose rates as low as 10 nGy/s, the selection of each single element composing a typical PSD dosimetry system was revisited. A photon-counting photomultiplier tube (PMT) was used in combination with an optical fiber designed to collect more light from the scintillator. A spectral study was performed to determine the best combination of scintillator and optical fiber to use.
Finally, doses up to a distance of 6.5 cm from a single I-125 source of 0.76U (0.6 mCi) held at the center of a water phantom were measured. The PSD was moved at different radial and longitudinal positions from the source using an in-house computer-controlled device developed for this study and allowing for sub-mm positioning accuracy. The measurements were compared to the expected values from the updated Task-Group 43 formalism.

Results: The change in the energy distribution with position around the I-125 source was shown from MC simulations to have a limited impact on the PSD's accuracy over the clinically relevant range (<1.2%). Therefore, the energy-dependence can be neglected, as long as the PSD is calibrated using the same isotope. The effect of the different materials on the photon energy distribution was also shown to be limited (<0.1%). The different improvements made to the PSD dosimetry system are presented in Table 1. Those led to a 44 times better signal-to-noise ratio than for a typical PSD. Measurements with the PSD around a single I-125 source were shown to be in good agreement with the expected values (see Fig.1). The uncertainty was shown to be a balance between positioning uncertainty near the source and measurement uncertainty as the detector moves farther away from the source.

Improvements		Factor
	Cooling PMT (reduction in dark noise)	1.6
	Selection of scintillator + Shorter fiber	5.7
	Using a Mylar reflector	2
NA = 0.6 vs. NA = 0.5	collected light	1.44
	increase in OPL	0.996
	Scintillator length (5 mm vs 3 mm)	1.67
Total		**43.75**

Table 1. Summary of the different improvements made to the PSD dosimetry system (PMT: Photomultiplier Tube, NA: Numerical aperture, OPL: optical path length).

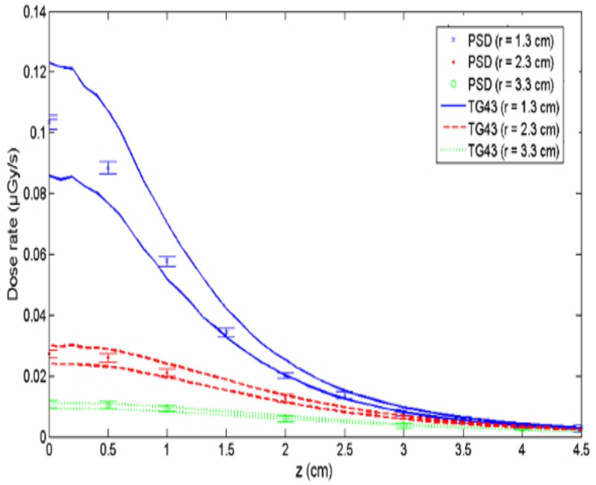

Figure 1. Measured dose-rate with the PSD as a function of position along the longitudinal axis of the source (z) for different radial distances (r) in comparison to the expected values (TG43). The TG43 values (lines) account for uncertainties in source-to-detector positioning of ±1 mm along the x- y- and z-axes.

Conclusion: This optimized PSD system was shown to be capable of accurate in-phantom dosimetry around a single LDR brachytherapy seed, which confirms the high sensitivity of the detector as a potential *in vivo* dosimeter for LDR brachytherapy applications.

OC-0254
MR compatibility of fiber optic sensing for real-time needle tracking

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